PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-050073
(43)Date of publication of application : 20.02.1996

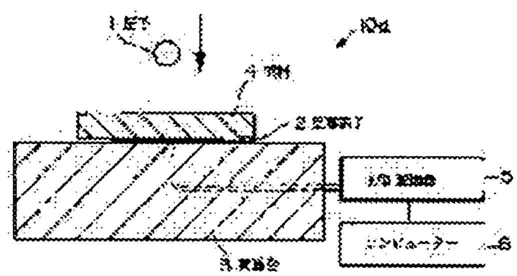
(51)Int.CI. G01L 25/00
G01B 21/32
G01N 3/30

(21)Application number : 06-205971
(22)Date of filing : 08.08.1994

(71)Applicant : TOYO TECHNO CORP:KK
(72)Inventor : ISOMOTO YOSHINORI

(54) METHOD AND APPARATUS FOR MEASURING STRESS-STRAIN BEHAVIOR

(57)Abstract:
PURPOSE: To obtain the accurate stress-strain curve of a sample at fast collision speed by solving a specific formula by calculating the relational curve of the load generated by allowing the pressure element to collide with the sample at arbitrary collision speed and the contact time of the sample and the pressure element.
CONSTITUTION: The relational curve of the load (F) generated by allowing a spherical pressure element 1 with an arbitrary radius (R) and mass (m) to collide with a sample 4 at arbitrary collision speed (V) and the contact time (t) of the sample 4 and the pressure element 1 is calculated. An equation of motion $dV/dt=F/m=--\alpha C/m$ is solved from the initial speed (V0) of the pressure element 1 and the boundary condition at a time when the pressure element 1 is stopped after the collision with the sample 4. Stress (P) is plotted on a vertical axis and a dent rate (d/D) being a ratio of the dent radius (d) of the sample 4 to the diameter (D) of the pressure element 1 is plotted on a horizontal axis to obtain a stress-strain curve.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]

[Claim 1] The load produced by a radius (R) being spherical in a sample (4), and making the indenter (1) of mass (m) collide with it at the collision rate (V) of arbitration (F), It asks for a related curve with the contact time (t) which is the time amount with said sample (4) and said indenter (1) which contacted. By solving a formula from boundary condition when the initial velocity (V0) of said indenter (1) and said indenter (1) stop after a collision in said sample (4), as shown below The stress strain behavior measuring method characterized by obtaining a stress-strain curve on an axis of ordinate (axis of abscissa) by plotting the rate (d/D) of a crater which is the ratio of the crater radius (d) in said sample [as opposed to the diameter (D) of said indenter (1) for stress (P)] (4) on an axis of abscissa (axis of ordinate). the equation of motion -- dV/dt=-F/m=-alphaC/m -- (1) it is .

It integrates with said formula (1) and is said formula by initial condition (at the time of

t= 0 V=V0).

When the A/D-conversion value (C) in the contact time (t) of arbitration is acquired and a load (F) is not acquired, it is from a formula (2) from boundary condition (at the time of

t=t1 V= 0),

Furthermore, the crater depth (x) of said sample (4) is by integrating with a formula (2),

Here, the touch area (A) of said indenter (1) is used, and contact pressure (P), i.e., stress,

is,

It becomes. the rate (d/D) of a crater which is the ratio of a crater diameter (d) to the diameter (D) of said indenter (1) equivalent to the distortion (epsilon) of said sample (4) -- the crater depth (x) -- using -- d/D=root {1-(1-x/R) 2} -- (5) ** -- it carries out.

Here, the A/D-conversion value (C) of a load (F) and a load (F) has the relation of F=alpha C, and alpha is a transform coefficient. V moreover, the rate (m/s) of an indenter (1) and R The radius (m) of an indenter (1) and F a load (N) and m the mass (kg) of an indenter (1), and t -- (s) and the contact time of an indenter (1) and a sample (4), and V0 The crater diameter (m) of a sample (4) and D make it as the diameter (m) of an indenter (1), and P makes the crater depth (m) of a sample (4), and d contact pressure (Pa), i.e.,

stress, for the initial velocity (m/s) of an indenter (1), and x.
[Claim 2] The stress strain behavior measuring method characterized by substituting and solving (x) which uses the following formulas (4a) and is calculated by said formula (3) instead of a formula (4) in a stress strain behavior measuring method according to claim 1.
P=F/A=F/{pi x (2 R-x)} -- (4a) [Claim 3] The stress strain behavior measuring method according to claim 1 or 2 which adds and solves the following formulas (6). When said contact time (t) is measured for a long time, it is set to (t'=betat, however beta> 1), and the last crater depth (x1) of said sample (4) is used here, and it is from boundary condition (at the time [t=t1 =t'] of /beta x=x1), and said formula (3),

A next door, and beta and t1 It can ask. Here, it is x1. It is the last crater depth (m) of a sample (4).
[Claim 4] A stress strain behavior measuring method given in either of claims 1-3 which obtain a stress-strain curve by adding and solving the following formulas (7), plotting said stress (P) on an axis of ordinate (axis of abscissa), and plotting the distortion (epsilon) of said sample (4) on an axis of abscissa (axis of ordinate). Here, the relation between said distortion (epsilon) and said rate (d/D) of a crater is epsilon=0.2 d/D-- (7). It carries out.
[Claim 5] A spherical indenter (1) and the indenter launcher which energizes said indenter (1) and is discharged, A load detection means to be stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4), and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2), The load base (3) in which said load detection means (2) is laid, and the A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of said indenter (1) -- since -- the stress strain behavior measuring device characterized by changing.
[Claim 6] A spherical indenter (1) and the indenter launcher which energizes said indenter (1) and is discharged, The plate to which it is stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4) (8), A load detection means to be stuck under said plate (8) and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2), The load base which lays said plate (8) and holds said load detection means (2) to the space in a crevice (3a) (3), The A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of said indenter (1) -- since -- the stress strain behavior measuring device characterized by changing.
[Claim 7] Said load detection means (2) is a stress strain behavior measuring device according to claim 5 or 6 electrically connected to said A/D converter (5) through amplifier (7).

[Claim 8] Said load detection means (2) is a stress strain behavior measuring device given in either of claims 5-7 which consist of a piezoelectric device or a strain gage.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the stress strain behavior measuring method and equipment for asking for the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate.
[0002]
[Description of the Prior Art] It is JIS as an approach of asking for a stress-strain curve conventionally. B There is the tension test (JIS Z 2241) or compression test method (JIS K 7208) in the low strain rate by the testing machine set to the 7721st grade. Moreover, there is the impact tension test or impact compression test method for asking for the stress-strain curve of the sample in a comparatively high strain rate using the blow rod as an approach. In order for all to obtain a stress-strain curve, first, it asks for aging of stress which broke by authentic-sample area the force measured by the strain gage etc., and the approach of converting elapsed time into distortion according to the prerequisite that the passing speed of a crosshead or a blow rod is fixed is taken.
[0003]
[Problem(s) to be Solved by the Invention] However, although load-contact time can be found using load detectors, such as a strain gage, by the above-mentioned conventional approach, it is difficult to ask for the displacement-contact time curve between the sample gage lengths directly. Therefore, a stress-strain curve cannot be obtained easily. Then, in order to obtain the variation rate corresponding to time amount generally, a sample is made distorted at a fixed rate. In order to obtain a stress-strain curve from an impact test, it is necessary to keep the rate under collision as constant as possible by enlarging a blow rod. However, by enlarging a blow rod, the collision rate is restrained and it becomes very difficult to obtain a high collision rate. Moreover, in a collision test, by the time a blow rod collides and stops, rate change will surely be produced. Therefore, the stress-strain curve obtained by the premise of colliding with constant speed has the problem of producing gross errors more in the high field of distortion. Then, this invention aims at offering the stress strain behavior measuring method and equipment which can obtain the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate.
[0004]
[Means for Solving the Problem] The load produced by the radius (R) of this invention being spherical in a sample (4), and making the indenter (1) of mass (m) collide at the collision rate (V) of arbitration (F), It asks for a related curve with the contact time (t) which is the time amount with said sample (4) and said indenter (1) which contacted. By solving a formula from boundary condition when the initial velocity (V0) of said indenter (1) and said indenter (1) stop after a collision in said sample (4), as shown below It is the stress strain behavior measuring method characterized by obtaining a stress-strain curve on an axis of ordinate (axis of abscissa) by plotting the rate (d/D) of a crater which is the ratio of the crater radius (d) in said sample [as opposed to the diameter (D) of said indenter (1) for stress (P)] (4) on an axis of abscissa (axis of ordinate). the equation of motion -- dV/dt=-F/m=-alphaC/m -- (1) it is .
It integrates with said formula (1) and is said formula by initial condition (at the time of

(1) は、

$$V=V_0-(1/m)\int_0^t F\,dt \quad \cdots (2)$$ となる。

t= 0 V=V0).

When the A/D-conversion value (C) in the contact time (t) of arbitration is acquired and a load (F) is not acquired, it is from a formula (2) from boundary condition (at the time of

$$\int_0^{t1} F\,dt=\alpha\int_0^{t1} C\,dt=mV_0 \quad \cdots (2a)$$ が得られ、αを決定できる。

t=t1 V= 0),

Furthermore, the crater depth (x) of said sample (4) is by integrating with a formula (2),

Here, the touch area (A) of said indenter (1) is used, and contact pressure (P), i.e., stress,

is,

It becomes. The crater depth (x) is used for the rate (d/D) of a crater which is the ratio of a crater diameter (d) to the diameter (D) of said indenter (1) equivalent to the distortion (epsilon) of said sample (4), and it is d/D=root {1-(1-x/R) 2}. -- (5)
Here, the A/D-conversion value (C) of a load (F) and a load (F) has the relation of F=alpha C, and alpha is a transform coefficient. V moreover, the rate (m/s) of an indenter (1) and R The radius (m) of an indenter (1) and F a load (N) and m the mass (kg) of an indenter (1), and t -- (s) and the contact time of an indenter (1) and a sample (4), and V0 The crater diameter (m) of a sample (4) and D make it as the diameter (m) of an indenter (1), and P makes the crater depth (m) of a sample (4), and d contact pressure (Pa), i.e., stress, for the initial velocity (m/s) of an indenter (1), and x.
[0005] Furthermore, the indenter launcher which this invention energizes a spherical indenter (1) and said indenter (1), and is discharged, A load detection means to be stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4), and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2), The load base (3) in which said load detection means (2) is laid, and the A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of said indenter (1) -- since -- it is the stress strain behavior measuring device characterized by changing.
[0006] Furthermore, the indenter launcher which this invention energizes a spherical indenter (1) and said indenter (1), and is discharged, The plate to which it is stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4) (8), A load detection means to be stuck under said plate (8) and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2),

The load base which lays said plate (8) and holds said load detection means (2) to the space in a crevice (3a) (3), The A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of said indenter (1) -- since -- it is the stress strain behavior measuring device characterized by changing.

[0007]

[Function] According to this invention, first, the blow means was made small and the spherical indenter 1 was used. By this, a collision rate can be raised and it can develop even to a supersonic field. However, rate change until it stops from collision initiation becomes large from immediately after a collision by making small the indenter 1 which is a blow means. Then, the spherical indenter 1 is made to collide with a sample 4, and a sample 4 is dented. The exact stress-strain curve at the time of contact of an indenter 1 can be obtained from the boundary condition when stopping, after initial condition in case it asks for the piezoelectric device 2 which is the load detection means stuck on the background of a sample 4, or the load-contact time curve detected by the strain gage 2 at this time, next an indenter 1 collides with a sample 4, and an indenter 1 colliding with a sample 4 by solving a predetermined equation.

[0008]

[Example] Hereafter, this invention is explained based on the example with reference to a drawing. Stress strain behavior measuring device 10a is shown in drawing 1 (a). The spherical indenter 1 is energized by the tear gas gun which is the indenter launcher which is not illustrated, and is discharged. The shot with a diameter of 3.18mm or the tungsten-carbide ball with a diameter of 3mm was used for the indenter 1. If an indenter launcher is equipment which energizes an indenter 1 and is discharged, it will not be limited to a tear gas gun. A sample 4 consists of metals, such as aluminum, and synthetic resin, and it collides with the discharged indenter 1. If the hardness ratio of the indenter 1 to a sample 4 is large, a measurement result will not be influenced of the quality of the material of an indenter 1. A load detection means consists of a piezoelectric device 2 or a strain gage 2, and outputs an electrical potential difference by the collision of the sample 4 to the indenter 1 stuck and discharged under the sample 4. The load base 3 lays the piezoelectric device 2 which is a load detection means, or a strain gage 2. A/D converter 5 is electrically connected to a piezoelectric device 2 or a strain gage 2. A computer 6 is equipment calculated based on the electrical potential difference which is electrically connected to A/D converter 5, is outputted from a piezoelectric device 2 or a strain gage 2, and is inputted through A/D converter 5. This result is displayed with a display unit, or is printed by the printer. The indenter rate measuring device which is not illustrated is equipment which measures the collision rate to the sample 4 of an indenter 1, and consists of two photodiodes etc.

[0009] Stress strain behavior measuring device 10b is shown in drawing 1 (b). Although the configuration of stress strain behavior measuring device 10a of drawing 1 (a) and most is common, it is stuck to a plate 8 under a sample 4, and is stuck to a piezoelectric device 2 or a strain gage 2 under a plate 8, a plate 8 is laid on the load base 3, and a piezoelectric device 2 or a strain gage 2 is located in the space in crevice 3a prepared in the load base 3. The ingredient of a plate 8 is not limited to nylon.

[0010] The load produced by the radius (R) of this invention approach being spherical in a sample 4, and making the indenter 1 of mass (m) collide at the collision rate (V) of

arbitration (F), By asking for a related curve with the contact time (t) which is the time amount with a sample 4 and an indenter 1 which contacted, and solving a formula from boundary condition when the initial velocity (V0) of an indenter 1 and an indenter 1 stop after colliding with a sample 4, as shown below It is the stress strain behavior measuring method characterized by obtaining a stress-strain curve on an axis of ordinate (axis of abscissa) by plotting the rate (d/D) of a crater which is the ratio of the crater radius (d) in the sample [as opposed to the diameter (D) of an indenter 1 for stress (P)] 4 on an axis of abscissa (axis of ordinate).
[0011] the equation of motion -- dV/dt=-F/m=-alphaC/m -- (1) it is .
It integrates with said formula (1) and is said formula by initial condition (at the time of

t= 0 V=V0).

When the A/D-conversion value (C) in the contact time (t) of arbitration is acquired and a load (F) is not acquired, it is from a formula (2) from boundary condition (at the time of

t=t1 V= 0),

Furthermore, the crater depth (x) of said sample (4) is by integrating with a formula (2),

Here, the touch area (A) of said indenter (1) is used, and contact pressure (P), i.e., stress,

is,

It becomes. The crater depth (x) is used for the rate (d/D) of a crater which is the ratio of a crater diameter (d) to the diameter (D) of the indenter 1 equivalent to the distortion (epsilon) of a sample 4, and it is d/D=root {1-(1-x/R) 2}. -- It is set to (5).
[0012] Here, the A/D-conversion value (C) of a load (F) and a load (F) has the relation of F=alpha C, and alpha is a transform coefficient. V moreover, the rate (m/s) of an indenter (1) and R The radius (m) of an indenter (1) and F a load (N) and m the mass (kg) of an indenter (1), and t -- (s) and the contact time of an indenter (1) and a sample (4), and V0 The crater diameter (m) of a sample (4) and D make it as the diameter (m) of an indenter (1), and P makes the crater depth (m) of a sample (4), and d contact pressure (Pa), i.e., stress, for the initial velocity (m/s) of an indenter (1), and x.
[0013] The procedure of asking for an above-mentioned stress-strain curve is shown in <u>drawing 2</u> (a), (b), (c), and (d). First, an indenter 1 is discharged from a tear gas gun, a sample 4 collides, and the thrust by this collision and the electrical potential difference corresponding to the contact time of an indenter 1 and a sample 4 are outputted from a piezoelectric device 2. When stress strain behavior measuring device 10a of <u>drawing 1</u> (a) is used, the relation of the contact time of the A/D-conversion value acquired through

A/D converter 5, and an indenter 1 and a sample 4 is shown in drawing 2 (a) as it is in the electrical potential difference outputted from the piezoelectric device 2. When stress strain behavior measuring device 10b of drawing 1 (b) is used, after the electrical potential difference outputted from the piezoelectric device 2 is amplified with amplifier 7, the relation of the A/D-conversion value and contact time which were acquired through A/D converter 5 is shown in drawing 2 (a).

[0014] Next, by carrying out graphical integration of drawing 2 (a), as shown in drawing 2 (b), the rate-contact time of an indenter 1 is acquired, and it is the initial velocity V0 of an indenter 1 here. It considers as the rate measured with the indenter rate measuring device which consists of a photodiode etc., and which is not illustrated. By furthermore carrying out graphical integration of drawing 2 (b), as shown in drawing 2 (c), the penetration depth of an indenter 1, i.e., the crater depth-contact time curve of a sample 4, is obtained. By surveying the last crater depth (x1) of the sample 4 by invasion in the sample 4 of an indenter 1 under a microscope The penetration depth of an indenter 1, i.e., the crater depth of a sample 4, (x) is called for, and the curve shown in drawing 2 (a), (b), (c), and (d) is called for by calculating the following equations (1), (2), (3), and (4) by computer 6.

[0015] Even if the load value corresponding to an A/D-conversion value is not known, all the related curves will be decided by an above-mentioned formula (2a) etc. according to initial condition and boundary condition. The contact pressure (stress) curve which broke the load in the contact time of arbitration by touch-area 2piRx as shown in an above-mentioned equation (4) comes to be shown in drawing 2 (d).

[0016] Furthermore, this invention approach is a stress strain behavior measuring method characterized by substituting and solving (x) which uses the following formulas (4a) and is calculated by said formula (3) instead of a formula (4) instead of a formula (4) in an above-mentioned stress strain behavior measuring method.

P=F/A=F/{pi x (2 R-x)} -- (4a) It can also consider that the value which broke the crater diameter by projected area {pi x (2 R-x)} of the crater at the time of being referred to as d instead of the touch area is also contact pressure, and evaluations differ. In this case, it is only that the denominators of a formula (4) differ and the procedure is completely the same.

[0017] Furthermore, this invention approach is a stress strain behavior measuring method which adds and solves the following formulas (6). When said contact time (t) is measured for a long time, it is set to (t'=betat, however beta> 1), and the last crater depth (x1) of said sample (4) is used here, and it is from boundary condition (at the time [t=t1 =t'] of /beta x=x1), and said formula (3),

A next door, and beta and t1 It can ask. Here, it is x1. It is the last crater depth (m) of a sample (4). With the load detection equipment shown in drawing 1 R> 1 (b), when a plate 8 bends, contact time becomes long, for example. However, as shown also in the procedure of drawing 2 (a), (b), (c), and (d), load-contact time is corrected according to boundary condition.

[0018] Furthermore, this invention is a stress strain behavior measuring method characterized by obtaining a stress-strain curve by adding and solving the following formulas (7), plotting said stress (P) on an axis of ordinate (axis of abscissa), and plotting the distortion (epsilon) of said sample (4) on an axis of abscissa (axis of ordinate). Here,

the relation between said distortion (epsilon) and said rate (d/D) of a crater is epsilon=0.2 d/D-- (7). It carries out.
It is based on this formula (7) and the experimental formula of Tabor (The Hardness of Metals.1951).
[0019] Drawing 3 (a) and (b) show the A/D-conversion value-contact time curve from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10a of drawing 1 (a) using a piezoelectric device 2, and a stress-contact time curve. Drawing 4 (a) and (b) show the A/D-conversion value-contact time curve from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10b of drawing 1 (b) using a piezoelectric device 2, and a stress-contact time curve. Although variation is looked at by the initial time amount of drawing 3 (a) and (b), this is because the uptake rate (microsecond) of an A/D converter is inadequate. In drawing 3 (a), (b), and drawing 4 (a) and (b), the difference among both is in elastic-deformation area size, and is regarded as the property of detection equipment. When a plate 8 is bent by stress strain behavior measuring device 10b of drawing 1 (b), as shown in drawing 4 (a), contact time is about 40 microseconds. It becomes. If the procedure of drawing 2 (a), (b), (c), and (d) is followed, as shown in drawing 4 (b), real contact time is in agreement with drawing 3 (a). These drawings show that an elastic-deformation field, the yield point, and a plastic deformation field all existing and ultimate strength are mostly in agreement.
[0020] Drawing 5 shows the stress-contact time curve in each collision rate from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10b of drawing 1 (b) using a piezoelectric device 2. Since there is no gage mark, rate of strain epsilon in the case of forming a crater by the collision of an indenter 1 does not suit the definition of JIS. Then, the following approximate expression (a) is used.
epsilon=0.18V1/2/[R(3P/2rho) 1 / 4] -- (a)
However, for v, a collision rate and R are [the hardness of a sample 4 and rho of the radius of an indenter 1 and P] the consistencies of a sample 4. For example, 13 m/s A strain rate in case the indenter 1 which changes from a 3.18mm shot to the sample 4 which consists of aluminum at a collision rate collides is 7.9x103 1/s. It becomes and is 2.4x104 1/s at 125 m/s. It becomes. Therefore, it is shown that the so-called elastic coefficient becomes small as, as for drawing 5 , a strain rate rises, and subsequent yield stress tends to become large. Moreover, the last stress became small, so that the strain rate was large.
[0021] Drawing 6 shows the stress-strain curve obtained by stress strain behavior measuring device 10b of drawing 1 (b) for which the indenter 1 used the shot with a diameter of 3.18mm and the strain gage 2. A sample 4 consists of aluminum, pure iron, or cast iron. The curve serves as right going up about every sample 4, and the inclination does not have great difference between samples 4. However, it turns out that a stress value changes with samples 4. Drawing 7 (a) and (b) show the stress-strain curve obtained by stress strain behavior measuring device 10b of drawing 1 (b) for which the indenter 1 used the tungsten-carbide ball with a diameter of 3.18mm and the piezoelectric device 2. A sample 4 consists of hardening carbon tool steel, temper carbon tool steel, pure iron, or cast iron. This drawing shows that a characteristic stress-strain curve is obtained according to the quality of the material of a sample 4. Although stress-strain curves differ by whether a piezoelectric device 2 or a strain gage 2 is used for the detection means of a load, this is based on the property of the detection means of a load.

[0022] As shown at drawing 8 (a) in drawing 7 (a) and (b), the case where an indenter 1 collided with the sample 4 which consists of hardening carbon tool steel at the rate of 150 m/s was shown, and the crack of a radial occurred from the outer-ring-of-spiral-wound-gasket section of a crater, and further, the ring-like crack occurred on the crater front face, and it ****ed after the collision of an indenter 1. Moreover, as shown in drawing 8 (b), the case where an indenter 1 collided with the sample 4 which consists of cast iron at the rate of 110 m/s was shown, and the detailed crack occurred caudad from the crater front face. Thereby, the fall of the stress after the yield point looked at by the stress-strain curve using a piezoelectric device 2 may be reflecting a crack and crack initiation. Drawing 9 shows the stress-strain curve by the compression test in the low strain rate which is the conventional approach performed according to JIS, and drawing 10 shows the stress-strain curve by the one example approach of this invention using the indenter 1 which consists of a shot with a diameter of 3.18mm. Both the samples 4 consist of aluminum. If an above-mentioned formula (7) is applied and it takes into consideration that the stress-strain curve by the compression test of the conventional approach is a nominal stress-nominal strain curve, except for the early stages of a crater, both inclination will carry out ******** coincidence. A stress value is pushed in and experimental is higher. This is because one example of this invention of drawing 10 is three-dimension compression to the compression test of the conventional approach being simple compression. Moreover, a view with nominal stress can also do the contact stress using projected area to the contact stress using a touch area being true stress.

[0023] Moreover, when drawing 10 is compared with drawing 5 , in the case of the sample 4 which consists of aluminum, the direction of a high strain rate has a large stress value, and it turns out that the effect of a strain rate has appeared well also to the behavior of a stress-strain curve. Generally the mechanical property of a sample changes with differences in a strain rate. However, by the impact test using a blow rod, they are 50 m/s. If it says at the following collision rates, i.e., a strain rate, it will be 104 (1-/s) extent and whenever [with it difficult / for equipment to become large-scale for obtaining more than it and a strain rate etc.] will be increased. It is also possible to obtain the stress-strain curve of more than 105 (1-/s), i.e., a supersonic field, by this invention. Moreover, creation of a sample is also easy and it can examine easily in rate of strain as usual.

[0024]

[Effect of the Invention] This invention does so the effectiveness that the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate, can be obtained, as explained above.

TECHNICAL FIELD

[Industrial Application] This invention relates to the stress strain behavior measuring method and equipment for asking for the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate.

PRIOR ART

[Description of the Prior Art] It is JIS as an approach of asking for a stress-strain curve conventionally. B There is the tension test (JIS Z 2241) or compression test method (JIS K 7208) in the low strain rate by the testing machine set to the 7721st grade. Moreover, there is the impact tension test or impact compression test method for asking for the stress-strain curve of the sample in a comparatively high strain rate using the blow rod as

an approach. In order for all to obtain a stress-strain curve, first, it asks for aging of stress which broke by authentic-sample area the force measured by the strain gage etc., and the approach of converting elapsed time into distortion according to the prerequisite that the passing speed of a crosshead or a blow rod is fixed is taken.

EFFECT OF THE INVENTION

[Effect of the Invention] This invention does so the effectiveness that the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate, can be obtained, as explained above.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, although load-contact time can be found using load detectors, such as a strain gage, by the above-mentioned conventional approach, it is difficult to ask for the displacement-contact time curve between the sample gage lengths directly. Therefore, a stress-strain curve cannot be obtained easily. Then, in order to obtain the variation rate corresponding to time amount generally, a sample is made distorted at a fixed rate. In order to obtain a stress-strain curve from an impact test, it is necessary to keep the rate under collision as constant as possible by enlarging a blow rod. However, by enlarging a blow rod, the collision rate is restrained and it becomes very difficult to obtain a high collision rate. Moreover, in a collision test, by the time a blow rod collides and stops, rate change will surely be produced. Therefore, the stress-strain curve obtained by the premise of colliding with constant speed has the problem of producing gross errors more in the high field of distortion. Then, this invention aims at offering the stress strain behavior measuring method and equipment which can obtain the exact stress-strain curve of the sample in a quick strain rate, i.e., a quick collision rate.

MEANS

[Means for Solving the Problem] The load produced by the radius (R) of this invention being spherical in a sample (4), and making the indenter (1) of mass (m) collide at the collision rate (V) of arbitration (F), It asks for a related curve with the contact time (t) which is the time amount with said sample (4) and said indenter (1) which contacted. By solving a formula from boundary condition when the initial velocity (V0) of said indenter (1) and said indenter (1) stop after a collision in said sample (4), as shown below It is the stress strain behavior measuring method characterized by obtaining a stress-strain curve on an axis of ordinate (axis of abscissa) by plotting the rate (d/D) of a crater which is the ratio of the crater radius (d) in said sample [as opposed to the diameter (D) of said indenter (1) for stress (P)] (4) on an axis of abscissa (axis of ordinate). the equation of motion -- dV/dt=-F/m=-alphaC/m -- (1) it is .
It integrates with said formula (1) and is said formula by initial condition (at the time of

t= 0 V=V0).

When the A/D-conversion value (C) in the contact time (t) of arbitration is acquired and a load (F) is not acquired, it is from a formula (2) from boundary condition (at the time of

t=t1 V= 0),

Furthermore, the crater depth (x) of said sample (4) is by integrating with a formula (2),

Here, the touch area (A) of said indenter (1) is used, and contact pressure (P), i.e., stress,

is,

It becomes. The crater depth (x) is used for the rate (d/D) of a crater which is the ratio of a crater diameter (d) to the diameter (D) of said indenter (1) equivalent to the distortion (epsilon) of said sample (4), and it is d/D=root {1-(1-x/R) 2}. -- (5)
Here, the A/D-conversion value (C) of a load (F) and a load (F) has the relation of F=alpha C, and alpha is a transform coefficient. V moreover, the rate (m/s) of an indenter (1) and R The radius (m) of an indenter (1) and F a load (N) and m the mass (kg) of an indenter (1), and t -- (s) and the contact time of an indenter (1) and a sample (4), and V0 The crater diameter (m) of a sample (4) and D make it as the diameter (m) of an indenter (1), and P makes the crater depth (m) of a sample (4), and d contact pressure (Pa), i.e., stress, for the initial velocity (m/s) of an indenter (1), and x.
[0005] Furthermore, the indenter launcher which this invention energizes a spherical indenter (1) and said indenter (1), and is discharged, A load detection means to be stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4), and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2), The load base (3) in which said load detection means (2) is laid, and the A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of said indenter (1) -- since -- it is the stress strain behavior measuring device characterized by changing.
[0006] Furthermore, the indenter launcher which this invention energizes a spherical indenter (1) and said indenter (1), and is discharged, The plate to which it is stuck under the sample (4) by which it collides with said discharged indenter (1), and a sample (4) (8), A load detection means to be stuck under said plate (8) and to output an electrical potential difference by the collision of said sample (4) to said discharged indenter (1) (2), The load base which lays said plate (8) and holds said load detection means (2) to the space in a crevice (3a) (3), The A/D converter electrically connected to said load detection means (2) (5), The computer calculated based on the electrical potential difference which is electrically connected to said A/D converter (5), is outputted from said load detection means (2), and is inputted through said A/D converter (5) (6), the indenter rate measuring device which measures the collision rate to said sample (4) of

said indenter (1) -- since -- it is the stress strain behavior measuring device characterized by changing.

OPERATION

[Function] According to this invention, first, the blow means was made small and the spherical indenter 1 was used. By this, a collision rate can be raised and it can develop even to a supersonic field. However, rate change until it stops from collision initiation becomes large from immediately after a collision by making small the indenter 1 which is a blow means. Then, the spherical indenter 1 is made to collide with a sample 4, and a sample 4 is dented. The exact stress-strain curve at the time of contact of an indenter 1 can be obtained from the boundary condition when stopping, after initial condition in case it asks for the piezoelectric device 2 which is the load detection means stuck on the background of a sample 4, or the load-contact time curve detected by the strain gage 2 at this time, next an indenter 1 collides with a sample 4, and an indenter 1 colliding with a sample 4 by solving a predetermined equation.

EXAMPLE

[Example] Hereafter, this invention is explained based on the example with reference to a drawing. Stress strain behavior measuring device 10a is shown in drawing 1 (a). The spherical indenter 1 is energized by the tear gas gun which is the indenter launcher which is not illustrated, and is discharged. The shot with a diameter of 3.18mm or the tungsten-carbide ball with a diameter of 3mm was used for the indenter 1. If an indenter launcher is equipment which energizes an indenter 1 and is discharged, it will not be limited to a tear gas gun. A sample 4 consists of metals, such as aluminum, and synthetic resin, and it collides with the discharged indenter 1. If the hardness ratio of the indenter 1 to a sample 4 is large, a measurement result will not be influenced of the quality of the material of an indenter 1. A load detection means consists of a piezoelectric device 2 or a strain gage 2, and outputs an electrical potential difference by the collision of the sample 4 to the indenter 1 stuck and discharged under the sample 4. The load base 3 lays the piezoelectric device 2 which is a load detection means, or a strain gage 2. A/D converter 5 is electrically connected to a piezoelectric device 2 or a strain gage 2. A computer 6 is equipment calculated based on the electrical potential difference which is electrically connected to A/D converter 5, is outputted from a piezoelectric device 2 or a strain gage 2, and is inputted through A/D converter 5. This result is displayed with a display unit, or is printed by the printer. The indenter rate measuring device which is not illustrated is equipment which measures the collision rate to the sample 4 of an indenter 1, and consists of two photodiodes etc.
[0009] Stress strain behavior measuring device 10b is shown in drawing 1 (b). Although the configuration of stress strain behavior measuring device 10a of drawing 1 (a) and most is common, it is stuck to a plate 8 under a sample 4, and is stuck to a piezoelectric device 2 or a strain gage 2 under a plate 8, a plate 8 is laid on the load base 3, and a piezoelectric device 2 or a strain gage 2 is located in the space in crevice 3a prepared in the load base 3. The ingredient of a plate 8 is not limited to nylon.
[0010] The load produced by the radius (R) of this invention approach being spherical in a sample 4, and making the indenter 1 of mass (m) collide at the collision rate (V) of arbitration (F), By asking for a related curve with the contact time (t) which is the time amount with a sample 4 and an indenter 1 which contacted, and solving a formula from

boundary condition when the initial velocity (V0) of an indenter 1 and an indenter 1 stop after colliding with a sample 4, as shown below It is the stress strain behavior measuring method characterized by obtaining a stress-strain curve on an axis of ordinate (axis of abscissa) by plotting the rate (d/D) of a crater which is the ratio of the crater radius (d) in the sample [as opposed to the diameter (D) of an indenter 1 for stress (P)] 4 on an axis of abscissa (axis of ordinate).

[0011] the equation of motion -- dV/dt=-F/m=-alphaC/m -- (1) it is .

It integrates with said formula (1) and is said formula by initial condition (at the time of

t= 0 V=V0).

When the A/D-conversion value (C) in the contact time (t) of arbitration is acquired and a load (F) is not acquired, it is from a formula (2) from boundary condition (at the time of

t=t1 V= 0),

Furthermore, the crater depth (x) of said sample (4) is by integrating with a formula (2),

Here, the touch area (A) of said indenter (1) is used, and contact pressure (P), i.e., stress,

is,

It becomes. The crater depth (x) is used for the rate (d/D) of a crater which is the ratio of a crater diameter (d) to the diameter (D) of the indenter 1 equivalent to the distortion (epsilon) of a sample 4, and it is d/D=root {1-(1-x/R) 2}. -- It is set to (5).

[0012] Here, the A/D-conversion value (C) of a load (F) and a load (F) has the relation of F=alpha C, and alpha is a transform coefficient. V moreover, the rate (m/s) of an indenter (1) and R The radius (m) of an indenter (1) and F a load (N) and m the mass (kg) of an indenter (1), and t -- (s) and the contact time of an indenter (1) and a sample (4), and V0 The crater diameter (m) of a sample (4) and D make it as the diameter (m) of an indenter (1), and P makes the crater depth (m) of a sample (4), and d contact pressure (Pa), i.e., stress, for the initial velocity (m/s) of an indenter (1), and x.

[0013] The procedure of asking for an above-mentioned stress-strain curve is shown in <u>drawing 2</u> (a), (b), (c), and (d). First, an indenter 1 is discharged from a tear gas gun, a sample 4 collides, and the thrust by this collision and the electrical potential difference corresponding to the contact time of an indenter 1 and a sample 4 are outputted from a piezoelectric device 2. When stress strain behavior measuring device 10a of <u>drawing 1</u> (a) is used, the relation of the contact time of the A/D-conversion value acquired through A/D converter 5, and an indenter 1 and a sample 4 is shown in <u>drawing 2</u> (a) as it is in the electrical potential difference outputted from the piezoelectric device 2. When stress

strain behavior measuring device 10b of drawing 1 (b) is used, after the electrical potential difference outputted from the piezoelectric device 2 is amplified with amplifier 7, the relation of the A/D-conversion value and contact time which were acquired through A/D converter 5 is shown in drawing 2 (a).

[0014] Next, by carrying out graphical integration of drawing 2 (a), as shown in drawing 2 (b), the rate-contact time of an indenter 1 is acquired, and it is the initial velocity V0 of an indenter 1 here. It considers as the rate measured with the indenter rate measuring device which consists of a photodiode etc., and which is not illustrated. By furthermore carrying out graphical integration of drawing 2 (b), as shown in drawing 2 (c), the penetration depth of an indenter 1, i.e., the crater depth-contact time curve of a sample 4, is obtained. By surveying the last crater depth (x1) of the sample 4 by invasion in the sample 4 of an indenter 1 under a microscope The penetration depth of an indenter 1, i.e., the crater depth of a sample 4, (x) is called for, and the curve shown in drawing 2 (a), (b), (c), and (d) is called for by calculating the following equations (1), (2), (3), and (4) by computer 6.

[0015] Even if the load value corresponding to an A/D-conversion value is not known, all the related curves will be decided by an above-mentioned formula (2a) etc. according to initial condition and boundary condition. The contact pressure (stress) curve which broke the load in the contact time of arbitration by touch-area 2piRx as shown in an above-mentioned equation (4) comes to be shown in drawing 2 (d).

[0016] Furthermore, this invention approach is a stress strain behavior measuring method characterized by substituting and solving (x) which uses the following formulas (4a) and is calculated by said formula (3) instead of a formula (4) instead of a formula (4) in an above-mentioned stress strain behavior measuring method.

P=F/A=F/{pi x (2 R-x)} -- (4a) It can also consider that the value which broke the crater diameter by projected area {pi x (2 R-x)} of the crater at the time of being referred to as d instead of the touch area is also contact pressure, and evaluations differ. In this case, it is only that the denominators of a formula (4) differ and the procedure is completely the same.

[0017] Furthermore, this invention approach is a stress strain behavior measuring method which adds and solves the following formulas (6). When said contact time (t) is measured for a long time, it is set to (t'=betat, however beta> 1), and the last crater depth (x1) of said sample (4) is used here, and it is from boundary condition (at the time [t=t1 =t'] of /beta x=x1), and said formula (3),

A next door, and beta and t1 It can ask. Here, it is x1. It is the last crater depth (m) of a sample (4). With the load detection equipment shown in drawing 1 R> 1 (b), when a plate 8 bends, contact time becomes long, for example. However, as shown also in the procedure of drawing 2 (a), (b), (c), and (d), load-contact time is corrected according to boundary condition.

[0018] Furthermore, this invention is a stress strain behavior measuring method characterized by obtaining a stress-strain curve by adding and solving the following formulas (7), plotting said stress (P) on an axis of ordinate (axis of abscissa), and plotting the distortion (epsilon) of said sample (4) on an axis of abscissa (axis of ordinate). Here, the relation between said distortion (epsilon) and said rate (d/D) of a crater is epsilon=0.2 d/D-- (7). It carries out.

It is based on this formula (7) and the experimental formula of Tabor (The Hardness of Metals.1951).
[0019] Drawing 3 (a) and (b) show the A/D-conversion value-contact time curve from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10a of drawing 1 (a) using a piezoelectric device 2, and a stress-contact time curve. Drawing 4 (a) and (b) show the A/D-conversion value-contact time curve from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10b of drawing 1 (b) using a piezoelectric device 2, and a stress-contact time curve. Although variation is looked at by the initial time amount of drawing 3 (a) and (b), this is because the uptake rate (microsecond) of an A/D converter is inadequate. In drawing 3 (a), (b), and drawing 4 (a) and (b), the difference among both is in elastic-deformation area size, and is regarded as the property of detection equipment. When a plate 8 is bent by stress strain behavior measuring device 10b of drawing 1 (b), as shown in drawing 4 (a), contact time is about 40 microseconds. It becomes. If the procedure of drawing 2 (a), (b), (c), and (d) is followed, as shown in drawing 4 (b), real contact time is in agreement with drawing 3 (a). These drawings show that an elastic-deformation field, the yield point, and a plastic deformation field all existing and ultimate strength are mostly in agreement.
[0020] Drawing 5 shows the stress-contact time curve in each collision rate from which the shot with a diameter of 3.18mm and the sample 4 consisted of aluminum, and the indenter 1 was obtained by stress strain behavior measuring device 10b of drawing 1 (b) using a piezoelectric device 2. Since there is no gage mark, rate of strain epsilon in the case of forming a crater by the collision of an indenter 1 does not suit the definition of JIS. Then, the following approximate expression (a) is used.
epsilon=0.18V1/2/[R(3P/2rho) 1 / 4] -- (a)
However, for v, a collision rate and R are [the hardness of a sample 4 and rho of the radius of an indenter 1 and P] the consistencies of a sample 4. For example, 13 m/s A strain rate in case the indenter 1 which changes from a 3.18mm shot to the sample 4 which consists of aluminum at a collision rate collides is 7.9x103 1/s. It becomes and is 2.4x104 1/s at 125 m/s. It becomes. Therefore, it is shown that the so-called elastic coefficient becomes small as, as for drawing 5 , a strain rate rises, and subsequent yield stress tends to become large. Moreover, the last stress became small, so that the strain rate was large.
[0021] Drawing 6 shows the stress-strain curve obtained by stress strain behavior measuring device 10b of drawing 1 (b) for which the indenter 1 used the shot with a diameter of 3.18mm and the strain gage 2. A sample 4 consists of aluminum, pure iron, or cast iron. The curve serves as right going up about every sample 4, and the inclination does not have great difference between samples 4. However, it turns out that a stress value changes with samples 4. Drawing 7 (a) and (b) show the stress-strain curve obtained by stress strain behavior measuring device 10b of drawing 1 (b) for which the indenter 1 used the tungsten-carbide ball with a diameter of 3.18mm and the piezoelectric device 2. A sample 4 consists of hardening carbon tool steel, temper carbon tool steel, pure iron, or cast iron. This drawing shows that a characteristic stress-strain curve is obtained according to the quality of the material of a sample 4. Although stress-strain curves differ by whether a piezoelectric device 2 or a strain gage 2 is used for the detection means of a load, this is based on the property of the detection means of a load.
[0022] As shown at drawing 8 (a) in drawing 7 (a) and (b), the case where an indenter 1 collided with the sample 4 which consists of hardening carbon tool steel at the rate of 150

m/s was shown, and the crack of a radial occurred from the outer-ring-of-spiral-wound-gasket section of a crater, and further, the ring-like crack occurred on the crater front face, and it ****ed after the collision of an indenter 1. Moreover, as shown in drawing 8 (b), the case where an indenter 1 collided with the sample 4 which consists of cast iron at the rate of 110 m/s was shown, and the detailed crack occurred caudad from the crater front face. Thereby, the fall of the stress after the yield point looked at by the stress-strain curve using a piezoelectric device 2 may be reflecting a crack and crack initiation. Drawing 9 shows the stress-strain curve by the compression test in the low strain rate which is the conventional approach performed according to JIS, and drawing 10 shows the stress-strain curve by the one example approach of this invention using the indenter 1 which consists of a shot with a diameter of 3.18mm. Both the samples 4 consist of aluminum. If an above-mentioned formula (7) is applied and it takes into consideration that the stress-strain curve by the compression test of the conventional approach is a nominal stress-nominal strain curve, except for the early stages of a crater, both inclination will carry out ******** coincidence. A stress value is pushed in and experimental is higher. This is because one example of this invention of drawing 10 is three-dimension compression to the compression test of the conventional approach being simple compression. Moreover, a view with nominal stress can also do the contact stress using projected area to the contact stress using a touch area being true stress.
[0023] Moreover, when drawing 10 is compared with drawing 5 , in the case of the sample 4 which consists of aluminum, the direction of a high strain rate has a large stress value, and it turns out that the effect of a strain rate has appeared well also to the behavior of a stress-strain curve. Generally the mechanical property of a sample changes with differences in a strain rate. However, by the impact test using a blow rod, they are 50 m/s. If it says at the following collision rates, i.e., a strain rate, it will be 104 (1-/s) extent and whenever [with it difficult / for equipment to become large-scale for obtaining more than it and a strain rate etc.] will be increased. It is also possible to obtain the stress-strain curve of more than 105 (1-/s), i.e., a supersonic field, by this invention. Moreover, creation of a sample is also easy and it can examine easily in rate of strain as usual.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the fragmentary sectional view of the stress strain behavior measuring device of the example of this invention.
[Drawing 2] It is the related curvilinear Fig. of the indenter by the stress strain behavior measuring method of the example of this invention, the contact time of a sample, and an A/D-conversion value, an indenter rate, the crater depth and stress.
[Drawing 3] It is the related curvilinear Fig. of the indenter by the stress strain behavior measuring method of the example of this invention, the contact time of a sample, and an A/D-conversion value and stress.
[Drawing 4] It is the related curvilinear Fig. of the indenter by the stress strain behavior measuring method of the example of this invention, the contact time of a sample, and an A/D-conversion value and stress.
[Drawing 5] It is the related curvilinear Fig. of the stress and distortion by the stress strain behavior measuring method of the example of this invention.
[Drawing 6] It is the related curvilinear Fig. of the stress and distortion by the stress strain behavior measuring method of the example of this invention.
[Drawing 7] It is the related curvilinear Fig. of the stress and distortion by the stress

strain behavior measuring method of the example of this invention.
[Drawing 8] It is the crater condition explanatory view of the sample by the stress strain behavior measuring method of the example of this invention.
[Drawing 9] It is the related curvilinear Fig. of the stress and distortion by the conventional approach.
[Drawing 10] It is the related curvilinear Fig. of the stress and distortion by the stress strain behavior measuring method of the example of this invention.
[Description of Notations]
1 Indenter 2 Piezoelectric Device 3 Load Base 4 Sample
5 A/D Converter 6 Computer
7 Amplifier 8 Plate